Advanced Development of a Laser Bathymetry System

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LONG-TERM GOAL

The long range goals of this program fall into several areas: 1) Operational, 2) Scientific, 3) Computational. In an operational sense, we seek to demonstrate the feasibility and field deployable ability of a new type of 3-dimensional underwater imaging system which is based on using solid state components instead of mechanical ones. In a scientific sense we seek to understand the propagation of light in the coastal environment in which this imaging system will operate. This will include the deployment of the system in the CoBOP field program and will take advantage of the large amount of auxiliary data that will be collected in this program. In a computational sense, we seek to develop processing algorithms to optimize the quality of information that is being sensed optically. Using the output from the solid state imaging array, we will be able to construct a record of the time varying radiance that is incident upon the camera. Using this information in conjunction with the environmental data that will be collected, we will test the system's capability to simultaneously estimate both the environment and also the reflectivity and topography of the bottom, especially with respect to finding man made items.

OBJECTIVES

The objective of this past year of our program was to both test the sensor in our deep tank here at SIO as well as on a field expedition as well as to continue our development of singnal and image processing algorithms to refine the output of the data.

APPROACH

Our basic approach here was to simply take the instrument and deploy it in controlled environmental environments (in our test tank) as well as to deploy it on a recent expedition to the Caribbean on a field expedition.

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WORK COMPLETED

During the past 4 years of project funding, we have created a seagoing version of the L-Bath laser bathymetry system which has yielded promising results in both the laboratory and also the field. Figure 1 shows one of our more dramatic pictures, a recent image that was obtained by displaying the 3-dimensional data that was obtained after analysis of L-Bath data obtained from scanning a Manta Mine on the Scripps Pier. Additional images that have been collected in the water are the results of several years of both tank test data and the results of a successful field expedition to the Caribbean in conjunction with the CoBOP field program this past spring (1999).

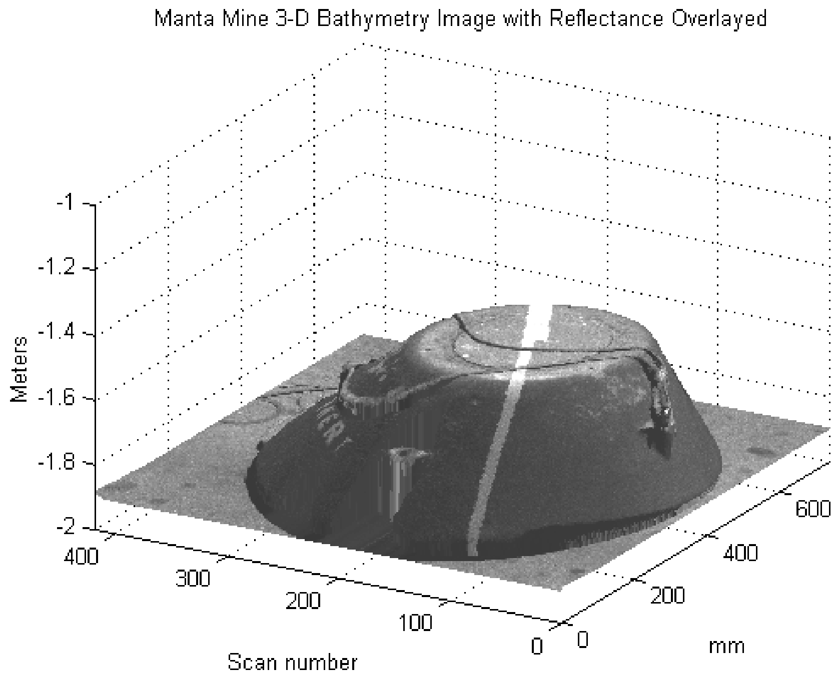

Figure 1: A rendering of the three dimensional data set of the Manta Mine

RESULTS

During our Caribbean cruise this past spring, our system was deployed and worked flawlessly for a period of 1 week. The system was deployed in two manners: (1) from the underwater translation device that was funded by our additional program with biological and chemical oceanography as part of the high frequency DRI and (2) by towing behind the R/V Calanus (U. of Miami) at speeds of up to 3 knots. As a result of this field operation, we collected approximately 40 Gbytes of excellent field data which consisted of hundreds of images of coral reefs, sand waves, turtle grass and stromatolites. In addition, several images of underwater mines were obtained. Additional efforts in our group reduced these data sets to bathymetry maps that are geometrically correct. Several examples of three dimensional animations of the data are available on our web site: http:\\pandora.ucsd.edu. Here one can find an animation of the above manta mine in three dimensions after geometric correction as well as three dimensional images of sea grasses and a large sand wave (50 meters) that we mapped from our towed operation.

An additional example of our first efforts to image bottom mines with the system is shown in Figure 2. Here we have labeled a torpedo shaped object (a Mine) sitting proud in a region which is mostly occupied by a coral reef. The mine has a distinct cylindrical shape which should make it easily recognizable by advanced algorithms which are tuned to look for such structures.

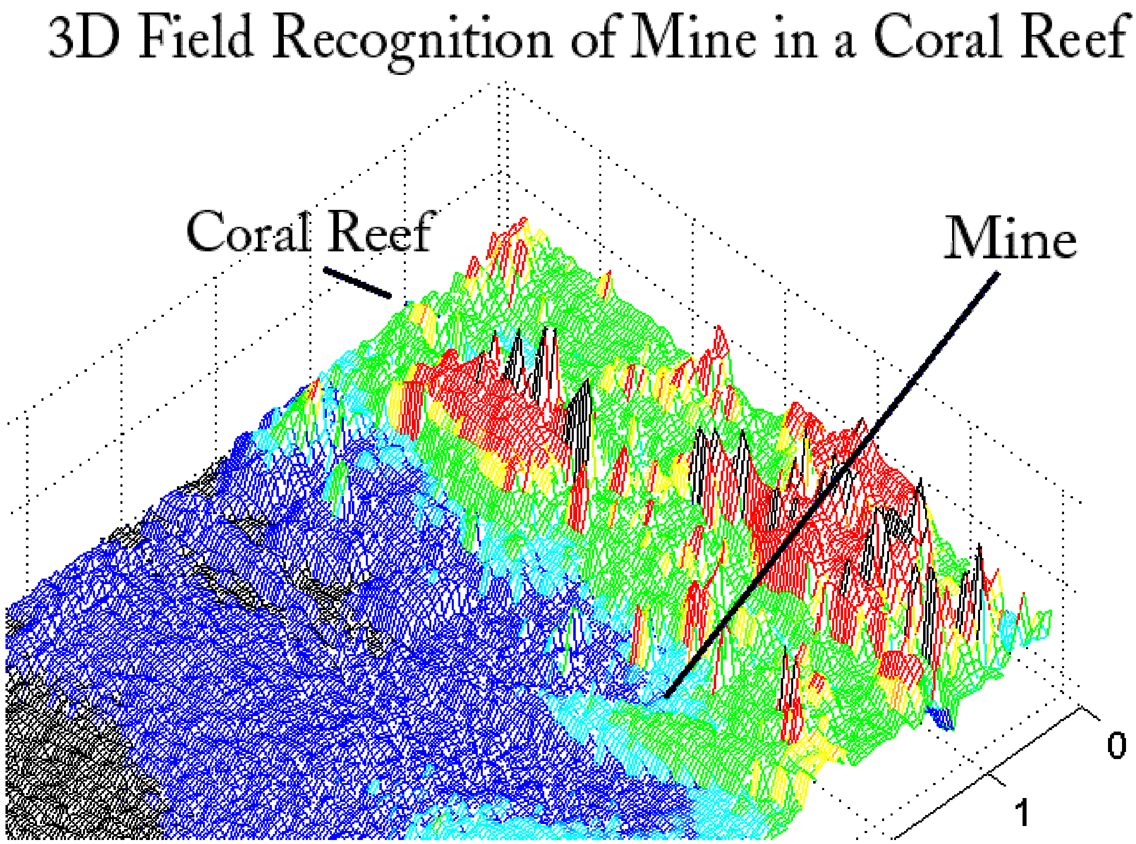

Figure 2: A three dimensional map of a mine on the sea floor in an area of coral reefs.

IMPACT/APPLICATIONS

We anticipate that the system will have both military and scientific value. From the scientific point of view there are a host of scientific subjects which can be imaged with our device. Examples are benthic animals which are sitting on the sea floor, sea grasses, coral reefs, as well as fish which are suspended over the bottom. From the military's point of view, the addition of this system to the already existing arsenal of underwater imaging tools should make a difference. First of all, this is the first device, to our knowledge, which will allow extended range imaging in concert with measurement of three dimensional shape. As such, the system can infer the exact size of objects since the three dimensional shape is available. This will be important for exact measurement of objects on the sea floor. We have also started to explore the application of the system to the measurement of surface waves from above the sea. Much to our pleasant surprise, the system was able to easily measure the height of these waves as 1 meter swells adjacent to the SIO pier. Figure 3 shows such an image of sea surface topology that has been measured with our system.

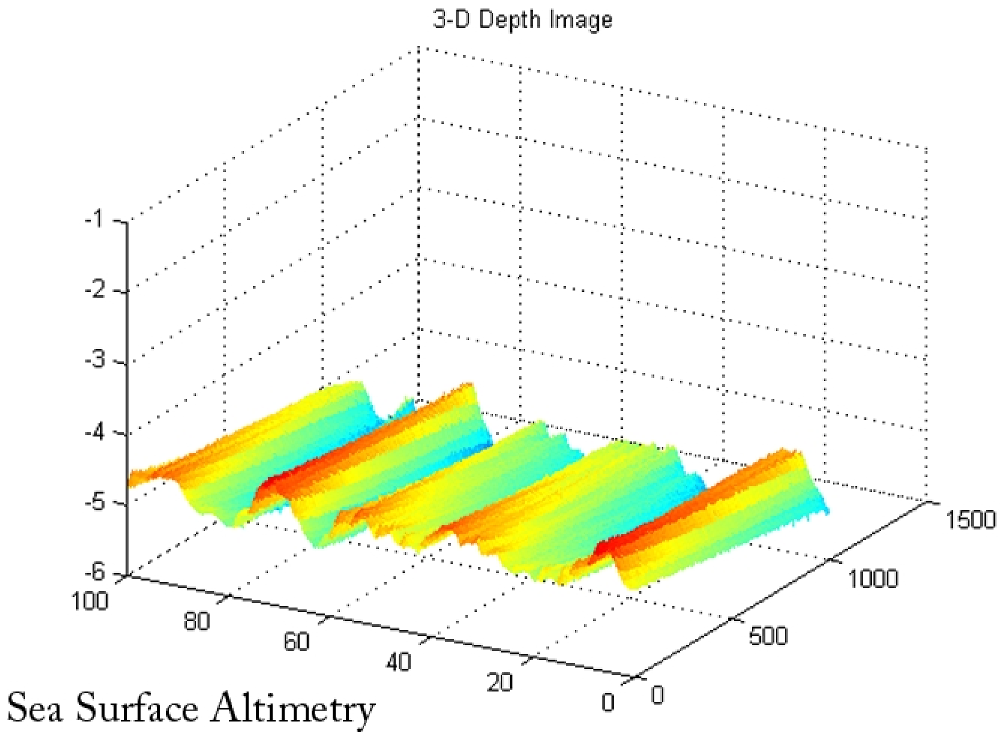

Figure 3: A set of measurements of sea surface altitude from the system when suspended above the sea surface at the SIO Pier. Vertical axis is range below the device in meters. Horizontal axes are (scan number (0 – 100)) and cross range location, roughly equivalent to 2 meters.

TRANSITIONS

The project has already accomplished a transition in that we are using the instrument as a part of the high frequency acoustic backscatter DRI under the bio-chem, geology, acoustics programs. Field data acquired during the fall operation for this program met our goal of millimeter resolution in both one and two dimensional scans. In addition, we have received some interest from both industry in licensing the ideas related to the device and also from other NAVY sponsored labs (APL-JH) in duplicating our hardware.

RELATED PROJECTS

The project is related to both the high frequency DRI and the COBOP DRI. As part of COBOP, this past spring we mapped a great many underwater features such as coral reefs, sea grasses, stromatolites, and large sandy areas. Ancillary measurements, taken by members of the COBOP team concern bottom sediment cores, observation of inherent optical properties and the orientation of sea grasses in flow. Our system spans an interesting domain in that our bathymetric resolution is much higher than currently obtainable with acoustics. However the presence of a high resolution bathymetry set provides the opportunity for examining the relationships of both kinds of information. In addition, the community of scientists examining the PHILS hyperspectral bottom reflectance data are interested in comparing our bottom measurements with the aircraft images.

PUBLICATIONS

Moore, K. D., J.S. Jaffe and B. L. Ochoa. Development of a new underwater bathymetric laser imaging system: L-Bath. J. Atmos. and Oceanic Tech., 40 ms. pgs. (1998). (accepted, subject to revision)